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Occupation and Risk of Meningioma and Acoustic Neuroma in the United States

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Background *Workplace exposures may be related to the development of brain tumors. In this case-control study, we examine occupation as a risk factor for meningioma and acoustic neuroma.*

Methods *A lifetime work history was obtained for 197 incident cases of meningioma, 96 cases of acoustic neuroma and 799 controls with non-malignant diseases enrolled from three hospitals in the United States between 1994 and 1998. Jobs considered to have similar tasks and chemical exposures were assigned to an occupational group. Logistic regression was used to estimate odds ratios (OR) adjusted for study matching factors (hospital, age, sex, race/ethnicity, and proximity of residence to the hospital) and education.*

Results *Elevated risk of meningioma was observed for individuals who had ever worked in the following occupational groups: auto body painters, designers and decorators, military occupations, industrial production supervisors, teachers, and managers. For acoustic neuroma, increased risk was noted for having worked as an athlete, gas station attendant, purchasing agent, sales representative, or teacher.*

Conclusions *Although limited by multiple comparisons and the relatively small number of cases and controls in many occupational groups, these results nevertheless provide clues that deserve additional study in future epidemiologic studies.* Am. J. Ind. Med. 45:395–407, 2004. *Published 2004 Wiley-Liss, Inc.*†

KEY WORDS: brain; tumor; case-control; occupation

INTRODUCTION

It is estimated that 35,519 new primary tumors of the brain and central nervous system were diagnosed in the United States in 2001. Approximately 26% of these tumors were meningiomas and 7% were nerve sheath tumors (including acoustic neuroma) [CBTRUS, 2000]. The existing epidemiologic literature on brain tumors focuses largely on risk of glioma (the most common major tumor category), or on risk of all brain cancers. Much less has been published on meningioma or acoustic neuroma. Although these are predominantly benign tumors, they can cause serious morbidity by virtue of their intra-cranial location. Compression of adjacent structures by meningiomas may cause a variety of neurological signs and symptoms, including headaches and seizures. The specific deficits depend on the exact location of the tumor. Acoustic neuromas may be characterized by tinnitus, hearing difficulties, and facial paresthesias [Kleihues and Cavenee, 2000]. A few studies have examined occupation as a risk factor for meningioma, and elevated risk has been reported for insurance agents,

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university lecturers, social workers, computer specialists, glassmakers, cooks, chemists, technicians, toolmaker setters and operators, inspectors, carpenters, gas station attendants, motor vehicle drivers, and machine operators [McLaughlin et al., 1987; Preston-Martin, 1989a; Menegoz et al., 2002; Navas-Acien et al., 2002]. Increased risk of acoustic neuroma has been associated with employment in occupations with loud noise exposure [Preston-Martin et al., 1989b]. Although meningioma and acoustic neuroma account for a sizable proportion of primary brain tumors, the epidemiological literature on these tumors is sparse. Possible associations between occupation and meningioma and acoustic neuroma deserve further study. This article examines occupation and risk of meningioma and acoustic neuroma using data from a large, hospital-based case-control study of brain tumors.

MATERIALS AND METHODS

Study Population

Subjects were enrolled for a case-control study of brain tumors between 1994 and 1998, in collaboration with three hospitals specializing in the treatment of brain tumors: St. Joseph's Hospital and Medical Center (including Barrow Neurological Institute) in Phoenix, Arizona; Brigham and Women's Hospital in Boston, Massachusetts; and Western Pennsylvania Hospital in Pittsburgh, Pennsylvania. The study protocol was approved by the Institutional Review Board of each participating institution, including the National Cancer Institute.

Eligible cases for the parent study were individuals of age 18 years or older with a first intra-cranial glioma, meningioma, or acoustic neuroma diagnosed within the 8 weeks during or preceding hospitalization. Since this analysis focuses on meningioma and acoustic neuroma, recruitment of glioma cases will not be described further. A detailed description of study methods can be found elsewhere [Inskip et al., 1999, 2001]. Ninety-four percent of eligible patients with meningioma and 93% of patients with acoustic neuroma agreed to participate in the study. All diagnosed meningiomas were confirmed by microscopy, as were 96% of acoustic neuromas. The remaining 4% of acoustic neuromas were confirmed by magnetic resonance imaging (MRI) or a computed tomographic (CT) scan.

Controls were patients admitted to the same hospitals as the cases for a variety of non-neoplastic conditions, with the most common being injuries (25%), circulatory system disorders (22%), musculoskeletal disorders (22%), and digestive disorders (12%). More than 90% of patients were interviewed within 1 year of symptom onset, and most of those within days or weeks of onset. Study controls were frequency-matched in a 1:1 ratio to all brain tumor cases based on hospital, sex, race/ethnicity, age, and proximity of residence to the hospital. Matching by proximity to hospital was conducted in order to try to obtain a sample from the underlying population of non-brain tumor cases that would have traveled to the same hospital as cases had they developed a brain tumor. Eighty-six percent of eligible controls participated in the study. Informed written consent was obtained from all cases and controls. A total of 197 subjects with meningioma and 96 subjects with acoustic neuroma were identified (out of 782 total brain tumor cases), along with 799 frequency-matched controls.

Work History Information

Shortly following hospitalization, a trained research nurse administered a structured in-person interview for each subject. Along with other risk factors, a detailed lifetime occupational history was collected for all subjects, including start and stop dates for every job held for at least 6 months after the age of 16 years, and job-specific questions developed by an industrial hygienist to assess the probability, frequency, duration and intensity of specific chemical and physical exposures in a given job [Stewart et al., 1996, 1998].

Occupational Coding

Initial coding of jobs was done using the 1980 Standard Occupational Coding (SOC) and the 1987 Standard Industrial Classification (SIC) schemes [Standard Occupational Classification Manual, 1980; Standard Industrial Classification Manual, 1987]. Based on the initial codes, jobs that were determined to have similar tasks and exposures were assembled into broader occupational groups by the study industrial hygienist (P.A.S.). Subjects in the case-control study were assigned to an occupational group without knowledge of case or control status.

Statistical Analysis

Statistical analyses were conducted separately for meningioma and acoustic neuroma. Following descriptive analyses of the data, unconditional logistic regression was used to estimate odds ratios (OR) and calculate 95% confidence intervals (CI) for each occupational group. Models were run for having ever worked in an occupational group, and for having worked in an occupational group for more than 5 years. The reference group comprised individuals who had never worked in the occupation. Due to incomplete information on work history, two controls (0.3%) were not included in the occupational analyses. Models estimating risk of meningioma were adjusted for study matching factors only (hospital, sex, race/ethnicity, age, and proximity of residence to the hospital). Education was thought a priori to be related to both occupation group and acoustic neuroma risk, and was found to significantly change estimates of risk

when specific occupations were evaluated in relation to acoustic neuroma. To control for confounding by education, this variable was included along with study matching factors in models relating occupation and acoustic neuroma. Adjustment variables were entered as indicator variables in the following categories: age in years (18–29; 30–39; 40–49; 50–59; 60–69; 70–79; 80–99); race/ethnicity (non-Hispanic white; Hispanic; African-American; other); sex (male, female); hospital (Phoenix, Boston, Pittsburgh); proximity of the patient's residence to the hospital in miles (0–4; 5–14; 15–29; 30–49; 50; or more); and education (less than high school graduate; high school graduate with or without some college; college graduate or more). Since unconditional logistic regression can yield biased results when strata are sparse, analyses for occupational groups were also conducted using conditional logistic regression [Breslow and Day, 1980]. Confidence intervals calculated under asymptotic assumptions were compared to exact confidence intervals for groups with small numbers per cell [Mehta et al., 2000]. If fewer than five individuals were present in an occupational group, estimates of risk were generally disregarded, since these estimates are likely to be highly unstable. However, if the OR for having ever worked in an occupational group was significantly elevated, results for having worked at least 5 years in that occupation were reported regardless of the number of subjects in that occupational group.

RESULTS

Demographic characteristics of meningioma and acoustic neuroma cases and controls are summarized in Table I. For most study matching factors, the distribution did not vary between meningioma cases and controls. Subjects with meningioma were more likely to be female, older, and from Boston. Acoustic neuroma cases were similar to controls with respect to race, but were more likely to be female and live more than 50 miles away from the hospital, were less likely to be in the two youngest age groups, and tended to be more educated than controls. Cases of acoustic neuroma were more likely to be diagnosed in Phoenix, Arizona. The differences between case and control distributions are mostly due to the fact that controls were matched on all tumors combined (including glioma), rather than on specific tumor sub-types.

Frequencies of cases and controls, and estimated associations between occupation and risk of meningioma are summarized in Table II. A report of having worked in any of the following occupational groups was associated with a significantly elevated risk of meningioma: automotive body painters (OR = 6.4, 95% CI = 1.0–40.2), designers and decorators (OR = 4.9, 95% CI = 1.0–22.7), managers not elsewhere classified (OR = 1.4, 95% CI = 1.0–2.1), military occupations (OR = 2.3, 95% CI = 1.0–5.0), industrial production managers and supervisors (OR = 3.6, 95% CI = 1.1–11.6), and teachers and instructors (OR = 1.6, 95% CI = 1.0–2.6). Risk of meningioma was also elevated for having worked in automotive body repair, although one out of the two cases of meningioma in this category had also worked as an auto body painter. Where data were available, risk of meningioma associated with working in the above occupations for 5 or more years tended to confirm the associations seen for having ever worked in those occupations, and even suggest stronger associations for those who worked longer in these occupations. Compared to never having worked in the occupation, working for more than 5 years was associated with increased risk for auto body repairers (OR = 14.2, 95% CI = 1.2–163.5), counselors, social workers, and psychologists (OR = 2.6, 95% CI = 1.0–6.4), designers and decorators (OR = 9.0, 95% CI = 1.0–81.6), military occupations (OR = 3.4, 95% CI = 0.8–14.5), managers not elsewhere classified (OR = 1.5, 95% CI = 1.0–2.3), store managers (OR = 4.3, 95% CI = 1.0–17.7), and teachers/instructors (OR = 1.8, 95% CI = 1.0–3.5).

Table III summarizes the estimated associations between occupational group and acoustic neuroma. The small number of subjects within most occupational groups reflects the relatively small sample size for these tumors and the wide representation of different occupations within the context of the hospital based case-control design. An increased risk of acoustic neuroma was observed for individuals who had ever worked as athletes or in related occupations such as athletic trainers or sports equipment demonstrators (OR = 12.1, 95% CI = 1.3–111.2). Designers and decorators also had an elevated risk of acoustic neuroma, with an OR of 5.5 for having ever worked in that occupation (95% CI = 0.9–35.3), and an OR of 28.5 (95% CI = 3.0–271.1) for having worked for 5 or more years. Statistically significant elevated risk was also observed for having ever worked as a gas station attendant (OR = 2.4, 95% CI = 1.0–6.0), purchasing agent (OR = 2.9, 95% CI = 1.0–8.8), sales representative (OR = 1.9, 95%CI = 1.0–3.5), or teacher/instructor (OR = 1.8, 95% CI = 1.0–3.5). Where data were available, working in these occupations for more than 5 years was associated with even greater elevated risk, although the increases were not statistically significant. Elevated risk of acoustic neuroma was observed for working for more than 5 years as an inspector/checker (OR = 6.6, 95% CI = 1.4–31.2) or mail clerk (OR = 52.5, 95% CI = 4.8–571.2).

Analyses for uncommon jobs using conditional logistic regression and calculation of exact confidence intervals [Breslow and Day, 1980; Mehta et al., 2000] generally produced OR of greater magnitude, and wider confidence intervals, than estimates from unconditional logistic regression with confidence intervals calculated under an asymptotic assumption (Table IV). Results that were previously significant at the $\alpha = 0.05$ level generally became significant at the $\alpha = 0.10$ level. Results of conditional and

TABLE I. Distributions of Meningioma and Acoustic Neuroma Cases and Controls With Respect to Selected Characteristics, NCI Brain Tumor Study, 1994–1998

Characteristic	Meningioma cases (n = 197)	Acoustic neuroma cases (n = 96)	Controls[a] (n = 799)
Sex			
Male	46 (23.4%)	36 (37.5%)	363 (45.4%)
Female	151 (76.7%)	60 (62.5%)	436 (54.6%)
Race/ethnicity			
White, non-Hispanic	163 (82.7%)	89 (92.7%)	715 (89.5%)
Hispanic	14 (7.1%)	6 (6.3%)	54 (6.8%)
Black	9 (4.6%)	0 (0.0%)	19 (2.4%)
Other	11 (5.6%)	1 (1.0%)	11 (1.4%)
Age (years)			
18–29	4 (2.0%)	3 (3.1%)	101 (12.6%)
30–39	28 (14.2%)	14 (14.6%)	146 (18.3%)
40–49	43 (21.8%)	27 (28.1%)	165 (20.7%)
50–59	45 (22.8%)	24 (25.0%)	149 (18.7%)
60–69	40 (20.3%)	16 (16.7%)	127 (15.9%)
70–79	29 (14.7%)	12 (12.5%)	87 (10.9%)
80–99	8 (4.1%)	0 (0.0%)	24 (3.0%)
Educational level[b]			
Less than high school graduate	24 (12.2%)	5 (5.3%)	105 (13.5%)
High school graduate with or without some college	125 (63.8%)	49 (51.6%)	479 (61.6%)
College graduate or advanced degree	47 (24.0%)	41 (43.2%)	194 (24.9%)
Missing data	1	1	21
Hospital site			
Phoenix, AZ	99 (50.3%)	72 (75.0%)	405 (50.7%)
Boston, MA	79 (40.1%)	22 (22.9%)	220 (27.5%)
Pittsburgh, PA	19 (9.6%)	2 (2.1%)	174 (21.8%)
Proximity of residence to hospital (miles)			
0–5	59 (30.0%)	22 (22.9%)	262 (32.8%)
5–15	56 (28.4%)	30 (31.3%)	229 (28.7%)
15–30	43 (21.8%)	17 (17.7%)	163 (20.4%)
30–50	17 (8.6%)	3 (3.1%)	59 (7.4%)
≥50	22 (11.2%)	24 (25.0%)	86 (10.8%)

[a]Controls were matched to the total case group including glioma, meningioma, and acoustic neuroma.
[b]Percentage based on non-missing values.

unconditional analyses were very similar when more than five cases were present per cell.

DISCUSSION

Our analysis of occupational group as a possible risk factor for meningioma and acoustic neuroma brought to light several associations previously unreported in the literature. Elevated risk for meningioma has not been previously reported in military personnel or in designers and decorators. Newly reported associations for acoustic neuroma are increased risk in athletes, gas station attendants, inspectors and examiners, purchasing agents, and sales representatives.

The main objective of this analysis was hypothesis generation, and the results should be viewed in that context. An important limitation of this study is the paucity of subjects in many occupational groups. This is not surprising given the relatively small sample sizes and the wide representation of different occupations within the context of the hospital based case-control design. The small numbers in many of the occupational groups precluded several potentially informative analyses, including analysis of individuals who worked for more than 10 years in an occupational groups, analysis by sex (given that meningioma incidence is more common in women than in men), analysis of intensity levels of exposures, or consideration of latency period (especially since

TABLE II. Estimated Associations Between Occupational Groups and Risk of Meningioma, NCI Brain Tumor Study, 1994–1998

	Ever worked in occupation			Worked 5 years in occupation		
Occupational group	**Cases (n = 197)**	**Controls (n = 797)**	**OR (95% CI)**	**Cases (n = 197)**	**Controls (n = 797)**	**OR (95% CI)**
Actors, dancers, and directors	0	3	—	0	0	—
Agricultural and food scientists and technicians	1	2	—	0	0	—
Aircraft mechanics	2	12	1.4 (0.3–6.5)	1	3	—
Airplane pilots and navigators	1	8	0.7 (0.1–5.7)	1	4	—
Animal caretakers	1	12	0.3 (0.0–2.5)	1	3	—
Artists	2	7	0.9 (0.2–4.6)	0	5	0.0 (0.0–.)
Asbestos workers	0	3	—	0	0	—
Assemblers and packers	13	40	1.1 (0.6–2.2)	3	7	1.7 (0.4–7.2)
Athletes and related occupations	0	3	—	0	1	—
Automotive body and related repairers	2	5	3.9 (0.7–21.8)	2	1	14.2 (1.2–163.5)[a]
Automotive body painters	2	4	6.4 (1.0–40.2)[a]	0	1	—
Brick masons and stone and tile setters	0	10	0.0 (0.0–.)	0	4	—
Butchers and meat cutters	2	8	1.0 (0.2–5.7)	0	3	—
Carpenters	2	22	0.6 (0.1–2.9)	0	10	0.0 (0.0–.)
Chemical industry workers	2	4	2.2 (0.4–14.0)	1	3	—
Chemists and chemical lab technicians	4	6	2.3 (0.6–9.0)	1	3	—
Child care workers	6	41	0.4 (0.2–1.1)	0	9	0.0 (0.0–.)
Clergy	0	8	0.0 (0.0–∞)	0	5	0.0 (0.0–.)
Clinical and biological lab scientists and technicians	6	12	1.6 (0.5–4.5)	4	5	2.0 (0.5–8.2)
Computer programmers and analysts	6	17	1.9 (0.7–5.2)	4	7	2.8 (0.8–10.6)
Concrete workers	2	8	2.3 (0.5–11.8)	0	4	—
Construction laborers	1	16	0.6 (0.1–5.0)	0	0	—
Construction managers	1	13	0.7 (0.1–5.7)	0	9	0.0 (0.0–.)
Construction workers	2	13	1.4 (0.3–6.7)	1	6	1.2 (0.1–11.3)
Cooks and kitchen workers	33	149	1.0 (0.7–1.6)	9	25	1.1 (0.5–2.6)
Counselors, social workers, and psychologists	12	30	1.3 (0.6–2.6)	10	12	2.6 (1.0–6.4)[a]
Dentists and dental assistants	2	10	0.8 (0.2–3.7)	2	3	1.9 (0.3–13.2)
Designers and decorators	4	4	4.9 (1.0–22.7)[a]	2	2	9.0 (1.0–81.6)[a,b]
Drafting occupations	3	7	2.6 (0.6–11.1)	1	1	—
Drivers (cars and light trucks)	7	30	1.4 (0.6–3.4)	3	8	3.2 (0.7–14.1)
Dry cleaner workers	1	14	0.1 (0.0–1.2)	0	3	—
Drywall and plaster workers	1	5	1.4 (0.1–13.8)	1	3	—
Editors, reporters, and writers	8	16	1.4 (0.6–3.5)	3	6	1.5 (0.3–6.4)
Electrical technicians, assemblers, and repairers	10	32	1.4 (0.7–3.1)	1	13	0.3 (0.0–2.1)
Electrical engineers	2	9	1.0 (0.2–4.9)	1	8	0.6 (0.1–5.4)
Electrical installers	1	6	1.1 (0.1–9.8)	1	2	—
Electricians	3	11	2.1 (0.5–7.8)	1	5	1.5 (0.2–13.0)
Embalmers	0	3	—	0	0	—
Engineering technicians	1	15	0.3 (0.0–2.3)	1	6	0.6 (0.1–5.6)
Engineers (NEC)	5	17	1.7 (0.6–5.0)	3	10	1.8 (0.5–7.1)
Equipment and parts cleaners	2	9	1.2 (0.2–6.6)	0	0	—
Exterminators	0	2	—	0	0	—
Fabricators (miscellaneous)	4	13	1.1 (0.3–3.6)	0	1	—
Firefighting occupations	0	7	0.0 (0.0–.)	0	4	—
Food industry workers	2	11	0.6 (0.1–2.9)	0	2	—
Forklift/crane operators	2	13	0.7 (0.1–3.9)	1	5	0.5 (0.0–6.2)

(*Continued*)

TABLE II. (*Continued*)

Occupational group	Ever worked in occupation			Worked 5 years in occupation		
	Cases (n = 197)	Controls (n = 797)	OR (95% CI)	Cases (n = 197)	Controls (n = 797)	OR (95% CI)
Gas station attendants	2	38	0.3 (0.1–1.5)	0	5	0.0 (0.0–.)
General farmers and farmworkers	7	18	2.0 (0.8–5.3)	3	5	2.0 (0.4–8.9)
General laborers	1	38	0.2 (0.0–1.5)	1	6	0.9 (0.1–7.7)
General maintenance or handymen	1	14	0.5 (0.1–4.0)	0	6	0.0 (0.0–.)
Glaziers and glass workers	0	2	—	0	0	—
Gluers	2	6	1.0 (0.2–5.8)	0	0	—
Groundskeepers, landscapers, and gardeners	2	21	0.7 (0.2–3.2)	1	2	—
Hairdressers, barbers, and cosmetologists	8	16	1.5 (0.6–3.9)	5	5	2.3 (0.6–8.5)
Health care management and administration	2	10	0.7 (0.1–3.3)	0	5	0.0 (0.0–.)
Health services occupations (NEC)	2	13	0.6 (0.1–2.7)	2	7	1.3 (0.2–7.3)
Health technicians (NEC)	1	15	0.3 (0.0–2.5)	1	6	0.8 (0.1–7.6)
Heavy equipment operators	1	11	0.7 (0.1–6.4)	0	5	0.0 (0.0–.)
Inspectors, checkers, examiners, graders, and testers	9	24	1.8 (0.8–4.1)	2	8	0.9 (0.2–5.3)
Investigators, examiners, adjustors, and appraisers	5	14	1.0 (0.3–2.8)	2	5	1.3 (0.2–6.9)
Janitors and custodians	4	26	1.1 (0.3–3.3)	1	4	1.2 (0.1–12.4)
Laundry workers	2	7	0.5 (0.1–2.6)	0	2	—
Librarians and library clerks	9	17	1.3 (0.6–3.2)	4	4	2.1 (0.5–9.3)
Livestock, dairy, poultry farmers, and farmworkers	2	11	1.0 (0.2–5.0)	0	2	—
Loggers and lumber workers	0	3	—	0	0	—
Machine operators and tenders (NEC)	2	16	0.5 (0.1–2.3)	2	5	1.2 (0.2–6.8)
Maids, housekeepers, and cleaners	10	29	0.9 (0.4–2.0)	3	9	0.5 (0.1–2.0)
Mail carriers and messengers	3	17	1.2 (0.3–4.3)	2	4	4.2 (0.6–28.9)
Mail clerks	2	15	0.6 (0.1–2.8)	0	3	—
Managers (NEC)	58	186	1.4 (1.0–2.1)[a]	41	122	1.5 (1.0–2.3)[a]
Managers, food service, and lodging	1	21	0.2 (0.0–1.6)	1	6	0.4 (0.1–3.9)
Managers, mechanics, and repairers	1	6	1.4 (0.2–12.8)	0	1	—
Marketing, advertising, and public relations	15	46	1.3 (0.7–2.4)	5	23	0.8 (0.3–2.1)
Mechanics and repairers (NEC)	3	37	0.6 (0.2–2.0)	1	11	0.6 (0.1–4.9)
Metal processing occupations	3	15	1.3 (0.3–5.2)	1	6	2.2 (0.2–19.5)
Metalworking occupations	3	30	0.6 (0.2–2.2)	0	11	0.0 (0.0–.)
Military occupations	10	35	2.3 (1.0–5.0)[a]	3	7	3.4 (0.8–14.5)
Mining workers	0	3	—	0	1	—
Musicians and composers	4	11	1.6 (0.5–5.3)	3	6	2.4 (0.5–10.7)
Nurses, registered and licensed practical	11	41	0.8 (0.4–1.7)	6	28	0.6 (0.3–1.6)
Nursing aides, orderlies, and attendants	20	59	1.1 (0.6–2.0)	8	15	1.6 (0.6–4.1)
Office clerks (NEC)	87	253	1.1 (0.8–1.6)	52	122	1.4 (0.9–2.1)
Office machine operators	2	6	1.0 (0.2–5.3)	0	2	—
Office professionals (NEC)	13	64	0.8 (0.4–1.6)	5	27	0.8 (0.3–2.1)
Officials and administrators, public programs and education	8	16	1.4 (0.6–3.4)	3	10	0.7 (0.2–2.8)
Painters	2	24	0.5 (0.1–2.2)	1	9	0.9 (0.1–7.2)
Paper industry workers	0	3	—	0	1	—
Personal service occupations (NEC)	5	26	0.9 (0.3–2.5)	1	2	—
Pharmacists	0	5	0.0 (0.0–.)	0	4	—
Photographers and photo processing	1	8	0.5 (0.1–4.0)	0	5	0.0 (0.0–.)
Physicians and physicians assistants	2	5	1.6 (0.3–10.5)	1	5	1.1 (0.1–10.5)

(*Continued*)

TABLE II. (*Continued*)

Occupational group	Ever worked in occupation			Worked 5 years in occupation		
	Cases (n = 197)	Controls (n = 797)	OR (95% CI)	Cases (n = 197)	Controls (n = 797)	OR (95% CI)
Plastics workers	0	7	0.0 (0.0–∞)	0	0	—
Plumbers, pipefitters, and steamfitters	1	12	0.7 (0.1–5.4)	1	5	1.4 (0.2–12.5)
Police, detectives, and guards	4	33	0.8 (0.3–2.5)	2	15	0.8 (0.2–3.7)
Power plant and boiler operators	0	8	0.0 (0.0–.)	0	2	—
Precision hand molders and shapers	0	3	—	0	1	—
Printers	5	13	1.8 (0.6–5.5)	2	3	5.3 (0.8–36.8)
Production managers and supervisors (industry)	5	10	3.6 (1.1–11.6)[a]	0	3	—
Property managers	3	6	1.4 (0.3–6.1)	1	2	—
Purchasing agents and buyers	5	14	1.1 (0.4–3.3)	2	5	1.1 (0.2–5.7)
Radio broadcasters, dispatchers, and air traffic controllers	5	33	0.9 (0.3–2.4)	1	12	0.4 (0.0–3.5)
Radiologic technicians	1	5	0.6 (0.1–5.5)	1	2	—
Railroad occupations	0	7	0.0 (0.0–.)	0	4	—
Recreation workers and physical education teachers	5	24	0.8 (0.3–2.3)	1	10	0.3 (0.0–2.3)
Researchers and research assistants (except lab)	4	8	2.2 (0.6–8.4)	1	5	0.6 (0.1–5.2)
Roofers	1	7	1.7 (0.2–14.7)	0	1	—
Sailors and fishermen	0	8	0.0 (0.0–.)	0	5	0.0 (0.0–.)
Sales clerks and cashiers	54	217	0.9 (0.6–1.4)	13	48	0.9 (0.4–1.7)
Sales representatives	22	66	1.4 (0.8–2.4)	10	25	1.8 (0.8–4.0)
Seamstresses and tailors	3	9	0.7 (0.2–3.0)	1	3	—
Shoemakers and leather workers	1	4	0.3 (0.0–3.2)	0	2	—
Stock handlers, shippers, and receivers	18	94	1.2 (0.7–2.2)	9	16	1.8 (0.7–5.0)
Store managers	7	20	1.0 (0.4–2.7)	5	4	4.3 (1.0–17.7)[a]
Teachers and instructors	32	72	1.6 (1.0–2.6)[a]	18	32	1.8 (1.0–3.5)[a]
Telephone and switchboard operators	10	30	0.9 (0.4–1.9)	3	6	1.2 (0.3–5.0)
Textile industry workers	6	14	0.9 (0.3–2.5)	2	7	0.5 (0.1–2.7)
Truck drivers (heavy)	14	63	1.5 (0.8–2.9)	7	26	1.6 (0.6–3.9)
Vehicle mechanics and repairers	3	22	0.9 (0.2–3.3)	2	12	1.3 (0.3–6.1)
Waiters and bartenders	32	115	1.0 (0.7–1.6)	11	34	1.2 (0.6–2.4)
Welders and cutters	1	18	0.2 (0.0–2.0)	0	4	—
Woodworkers	1	7	0.9 (0.1–7.6)	0	4	—

Models controlled for matching factors only. Reference group is individuals who have never worked in an occupation. Generally, results are shown only where the sum of exposed cases and exposed controls is greater than five.

[a]95% Confidence interval (CI) does not include 1.0.

[b]Number of exposed cases plus exposed controls is less than five.

meningiomas and acoustic neuromas are slow-growing tumors which do not always require immediate intervention). Broader definition of occupational groups might have increased size within groups, but at the expense of introducing additional heterogeneity in exposures.

Because study matching was conducted based on all tumor cases rather than individual tumor types, the subsetting of all brain tumors in order to study meningioma and acoustic neuroma led to a control distribution on the marginal factors that was quite dissimilar to that for the two tumor groups. Simply stratifying on the analysis factors in unconditional logistic regression could have produced biased estimates because of small strata [Breslow and Day, 1980]. When we re-examined associations using conditional logistic regression with exact confidence intervals (the appropriate analytic technique for frequency-matched case-control studies with sparse strata), we found that inference was quite similar to that based on unconditional logistic regression.

Another potential limitation is the use of a hospital-based case-control design. In a study with hospital controls,

TABLE III. Estimated Associations Between Occupational Groups and Risk of Acoustic Neuroma, NCI Brain Tumor Study, 1994–1998

	Ever worked in occupation			Worked 5 years in occupation		
Occupational group	**Cases (n = 96)**	**Controls (n = 797)**	**OR (95% CI)**	**Cases (n = 96)**	**Controls (n = 797)**	**OR (95% CI)**
Actors, dancers, and directors	1	3	—	1	0	—
Agricultural and food scientists and technicians	1	2	—	0	0	—
Aircraft mechanics	2	12	1.7 (0.3–8.7)	0	3	—
Airplane pilots and navigators	1	8	0.5 (0.1–4.1)	0	4	—
Animal caretakers	0	12	0.0 (0.0–.)	0	3	—
Artists	0	7	0.0 (0.0–.)	0	5	0.0 (0.0–.)
Asbestos workers	0	3	—	0	0	—
Assemblers and packers	3	40	0.7 (0.2–2.4)	1	7	1.6 (0.2–15.8)
Athletes and related occupations	2	3	12.1 (1.3–111.2)[a]	0	1	—
Automotive body and related repairers	0	5	0.0 (0.0–.)	0	1	—
Automotive body painters	0	4	—	0	1	—
Brick masons and stone and tile setters	0	10	0.0 (0.0–.)	0	4	—
Butchers and meat cutters	2	8	2.5 (0.4–14.1)	0	3	—
Carpenters	2	22	1.1 (0.2–5.4)	1	10	1.1 (0.1–10.6)
Chemical industry workers	1	4	1.6 (0.2–16.1)	0	3	—
Chemists and chemical lab technicians	2	6	2.1 (0.4–11.8)	1	3	—
Child care workers	5	41	1.0 (0.4–2.9)	2	9	1.5 (0.3–8.1)
Clergy	0	8	0.0 (0.0–.)	0	5	0.0 (0.0–.)
Clinical and biological lab scientists and technicians	1	12	0.5 (0.1–4.0)	0	5	0.0 (0.0–.)
Computer programmers and analysts	3	17	1.3 (0.3–4.8)	3	7	2.4 (0.6–10.9)
Concrete workers	0	8	0.0 (0.0–.)	0	4	—
Construction laborers	1	16	1.0 (0.1–8.6)	0	0	—
Construction managers	0	13	0.0 (0.0–.)	0	9	0.0 (0.0–.)
Construction workers	0	13	0.0 (0.0–.)	0	6	0.0 (0.0–.)
Cooks and kitchen workers	10	149	0.7 (0.3–1.5)	1	25	0.5 (0.1–4.1)
Counselors, social workers, and psychologists	4	30	0.9 (0.3–2.8)	0	12	0.0 (0.0–.)
Dentists and dental assistants	2	10	3.2 (0.6–17.1)	0	3	—
Designers and decorators	3	4	5.5 (0.9–35.3)	2	2	28.5 (3.0–271.1)[a,b]
Drafting occupations	2	7	2.7 (0.5–14.6)	1	1	—
Drivers (cars and light trucks)	4	30	1.8 (0.5–6.0)	1	8	3.8 (0.4–42.0)
Dry cleaner workers	4	14	2.0 (0.6–7.3)	1	3	—
Drywall and plaster workers	0	5	0.0 (0.0–.)	0	3	—
Editors, reporters, and writers	0	16	0.0 (0.0–.)	0	6	0.0 (0.0–.)
Electrical technicians, assemblers, and repairers	3	32	0.8 (0.2–2.7)	1	13	0.6 (0.1–4.9)
Electrical engineers	2	9	1.2 (0.2–6.3)	1	8	0.7 (0.1–6.3)
Electrical installers	0	6	0.0 (0.0–.)	0	2	—
Electricians	1	11	0.7 (0.1–5.6)	0	5	0.0 (0.0–.)
Embalmers	0	3	—	0	0	—
Engineering technicians	1	15	0.5 (0.1–4.4)	1	6	1.3 (0.2–12.2)
Engineers (NEC)	3	17	1.0 (0.3–3.9)	1	10	0.7 (0.1–6.0)
Equipment and parts cleaners	1	9	2.4 (0.3–22.8)	0	0	—
Exterminators	0	2	—	0	0	—
Fabricators (miscellaneous)	2	13	1.8 (0.4–8.6)	0	1	—
Firefighting occupations	0	7	0.0 (0.0–.)	0	4	—
Food industry workers	1	11	1.1 (0.1–9.6)	0	2	—
Forklift/crane operators	0	13	0.0 (0.0–.)	0	5	0.0 (0.0–.)
Gas station attendants	8	38	2.4 (1.0–6.0)[a]	2	5	3.8 (0.6–23.1)

(*Continued*)

TABLE III. (*Continued*)

Occupational group	Ever worked in occupation			Worked 5 years in occupation		
	Cases (n = 96)	Controls (n = 797)	OR (95% CI)	Cases (n = 96)	Controls (n = 797)	OR (95% CI)
General farmers and farmworkers	4	18	1.3 (0.4–4.4)	4	5	3.3 (0.8–13.7)
General laborers	3	38	0.8 (0.2–2.8)	1	6	1.8 (0.2–18.1)
General maintenance or handymen	2	14	1.4 (0.3–7.3)	1	6	1.6 (0.2–15.5)
Glaziers and glass workers	0	2	—	0	0	—
Gluers	0	6	0.0 (0.0–.)	0	0	—
Groundskeepers, landscapers, and gardeners	2	21	1.1 (0.2–5.3)	0	2	—
Hairdressers, barbers, and cosmetologists	3	16	1.5 (0.4–6.0)	1	5	1.0 (0.1–9.6)
Health care management and administration	1	10	0.6 (0.1–4.9)	0	5	0.0 (0.0–.)
Health services occupations (NEC)	4	13	2.8 (0.8–10.1)	2	7	6.9 (0.9–50.9)
Health technicians (NEC)	3	15	2.0 (0.5–8.0)	1	6	1.4 (0.1–13.5)
Heavy equipment operators	1	11	1.2 (0.1–10.7)	1	5	2.3 (0.2–23.8)
Inspectors, checkers, examiners, graders, and testers	4	24	2.0 (0.6–6.4)	3	8	6.6 (1.4–31.2)[a]
Investigators, examiners, adjustors, and appraisers	3	14	1.8 (0.5–6.8)	2	5	7.0 (0.9–53.4)
Janitors and custodians	3	26	1.4 (0.4–5.2)	1	4	4.0 (0.4–45.9)
Laundry workers	2	7	2.9 (0.5–16.6)	1	2	—
Librarians and library clerks	1	17	0.3 (0.0–2.4)	1	4	0.9 (0.1–9.6)
Livestock, dairy, poultry farmers, and farmworkers	1	11	0.5 (0.1–4.0)	1	2	—
Loggers and lumber workers	1	3	—	0	0	—
Machine operators and tenders (NEC)	1	16	0.8 (0.1–6.5)	1	5	2.5 (0.2–27.5)
Maids, housekeepers, and cleaners	3	29	1.0 (0.3–3.9)	1	9	1.2 (0.1–11.8)
Mail carriers and messengers	1	17	1.0 (0.1–8.2)	0	4	—
Mail clerks	3	15	2.8 (0.7–11.3)	2	3	52.5 (4.8–571.2)[a]
Managers (NEC)	27	186	0.8 (0.5–1.3)	17	122	0.7 (0.4–1.3)
Managers, food service, and lodging	3	21	1.1 (0.3–4.2)	2	6	2.4 (0.4–14.2)
Managers, mechanics, and repairers	2	6	3.4 (0.6–18.9)	0	1	—
Marketing, advertising, and public relations	5	46	0.6 (0.2–1.5)	1	23	0.2 (0.0–1.8)
Mechanics and repairers (NEC)	6	37	2.0 (0.7–5.3)	3	11	3.5 (0.8–14.5)
Metal processing occupations	0	15	0.0 (0.0–.)	0	6	0.0 (0.0–.)
Metalworking occupations	6	30	2.2 (0.8–5.9)	2	11	2.4 (0.5–12.5)
Military occupations	4	35	1.1 (0.3–3.5)	0	7	0.0 (0.0–.)
Mining workers	0	3	—	0	1	—
Musicians and composers	2	11	1.4 (0.3–7.1)	1	6	1.2 (0.1–11.3)
Nurses, registered and licensed practical	1	41	0.1 (0.0–1.0)	1	28	0.2 (0.0–1.4)
Nursing aides, orderlies, and attendants	7	59	0.9 (0.4–2.2)	2	15	1.2 (0.3–6.0)
Office clerks (NEC)	36	253	0.9 (0.5–1.5)	20	122	1.1 (0.6–2.1)
Office machine operators	1	6	0.9 (0.1–7.8)	0	2	—
Office professionals (NEC)	11	64	0.9 (0.4–1.9)	6	27	1.1 (0.4–2.9)
Officials and administrators, public programs and education	7	16	2.0 (0.7–5.7)	0	10	0.0 (0.0–.)
Painters	0	24	0.0 (0.0–.)	0	9	0.0 (0.0–.)
Paper industry workers	0	3	—	0	1	—
Personal service occupations (NEC)	1	26	0.4 (0.1–3.5)	0	2	—
Pharmacists	0	5	0.0 (0.0–.)	0	4	—
Photographers and photo processing	2	8	2.6 (0.5–14.1)	0	5	0.0 (0.0–.)
Physicians and physicians assistants	1	5	1.8 (0.2–20.5)	1	5	1.8 (0.2–20.5)
Plastics workers	2	7	3.4 (0.6–19.5)	0	0	—

(*Continued*)

TABLE III. (*Continued*)

Occupational group	Ever worked in occupation			Worked 5 years in occupation		
	Cases (n = 96)	Controls (n = 797)	OR (95% CI)	Cases (n = 96)	Controls (n = 797)	OR (95% CI)
Plumbers, pipefitters, and steamfitters	1	12	0.7 (0.1–5.9)	1	5	1.2 (0.1–12.2)
Police, detectives, and guards	3	33	1.1 (0.3–4.2)	1	15	0.7 (0.1–6.2)
Power plant and boiler operators	0	8	0.0 (0.0–.)	0	2	—
Precision hand molders and shapers	0	3	—	0	1	—
Printers	1	13	0.5 (0.1–4.4)	0	3	—
Production managers and supervisors (industry)	2	10	1.2 (0.2–6.0)	0	3	—
Property managers	2	6	2.3 (0.4–13.0)	1	2	—
Purchasing agents and buyers	6	14	2.9 (1.0–8.8)[a]	4	5	3.5 (0.9–14.5)
Radio broadcasters, dispatchers, and air traffic controllers	1	33	0.3 (0.0–2.3)	0	12	0.0 (0.0–.)
Radiologic technicians	2	5	1.4 (0.3–8.3)	1	2	—
Railroad occupations	0	7	0.0 (0.0–.)	0	4	—
Recreation workers and physical education teachers	7	24	1.9 (0.7–4.9)	4	10	2.1 (0.6–7.7)
Researchers and research assistants (except lab)	4	8	3.7 (0.9–15.1)	2	5	1.9 (0.3–11.3)
Roofers	0	7	0.0 (0.0–.)	0	1	—
Sailors and fishermen	0	8	0.0 (0.0–.)	0	5	0.0 (0.0–.)
Sales clerks and cashiers	24	217	0.9 (0.5–1.5)	4	48	0.9 (0.3–2.7)
Sales representatives	17	66	1.9 (1.0–3.5)[a]	5	25	1.4 (0.5–4.1)
Seamstresses and tailors	1	9	1.3 (0.1–12.2)	0	3	—
Shoemakers and leather workers	1	4	3.9 (0.3–44.0)	0	2	—
Stock handlers, shippers, and receivers	5	94	0.5 (0.2–1.3)	2	16	1.0 (0.2–4.7)
Store managers	4	20	1.4 (0.4–4.4)	1	4	0.8 (0.1–7.3)
Teachers and instructors	22	72	1.8 (1.0–3.5)[a]	10	32	1.7 (0.7–4.0)
Telephone and switchboard operators	1	30	0.2 (0.0–1.6)	0	6	0.0 (0.0–.)
Textile industry workers	1	14	0.6 (0.1–5.2)	1	7	0.8 (0.1–7.8)
Truck drivers (heavy)	4	63	0.6 (0.2–1.8)	2	26	0.9 (0.2–4.3)
Vehicle mechanics and repairers	2	22	1.0 (0.2–4.7)	0	12	0.0 (0.0–.)
Waiters and bartenders	12	115	0.8 (0.4–1.7)	4	34	1.2 (0.4–3.7)
Welders and cutters	2	18	1.0 (0.2–4.8)	1	4	2.1 (0.2–22.6)
Woodworkers	0	7	0.0 (0.0–.)	0	4	—

Models controlled for matching factors only. Reference group is individuals who have never worked in an occupation. Generally, results are shown only where the sum of exposed cases and exposed controls is greater than five.

[a]95% CI does not include 1.0.

[b]Number of exposed cases plus exposed controls is less than five.

differential rates of hospitalization for exposed and unexposed cases and controls can bias the OR determined in the hospital as compared to the true population OR [Schesselman, 1982; Wacholder et al., 1992]. A hospital-based design was chosen for the parent study since brain tumors (especially gliomas) often cause cognitive problems or death soon after diagnosis. Identification of newly diagnosed patients while they are in hospital for diagnostic work-up and/or treatment allows for more rapid interviewing of subjects than would be possible using a population-based approach. Direct interviewing of subjects provides more accurate information about a subject's exposure history compared to interviewing of proxy respondents. To minimize the possibility that any one control diagnosis would skew our measures of effect, we selected controls with a variety of conditions. A systematic bias in one sub-group of controls would hopefully not apply for controls with other medical conditions.

Despite its limitations, this study represents one of the largest case-control studies to date of meningioma and acoustic neuroma, two uncommon and understudied tumors. The participation rate among eligible subjects in this study

TABLE IV. Comparison of Results for Uncommon Occupational Groups Using Unconditional Logistic Regression and Conditional Logistic Regression, NCI Brain Tumor Study, 1994–1998

	Ever worked in occupation	
Occupational group	**Unconditional LR OR (95% CI)[a]**	**Conditional LR OR (95% CI)[b]**
Meningioma		
Automotive body painters	6.4 (1.0–40.2)	14.6 (0.8–865.2)
Designers and decorators	4.9 (1.0–22.7)	7.5 (0.7–387.2)
Production managers and supervisors (industry)	3.6 (1.1–11.6)	5.3 (1.1, 28.4)
Acoustic neuroma		
Athletes and related occupations	12.1 (1.3–111.2)	10.3 (0.8, ∞)
Gas station attendants	2.4 (1.0–6.0)	2.5 (0.8, 7.3)
Purchasing agents and buyers	2.9 (1.0–8.8)	4.2 (1.2, 14.7)

[a]Asymptotic assumption for calculation of confidence intervals.
[b]Exact confidence intervals.

was very high. Where data were available, we found that the risk of working in an occupation with elevated risk tended to be even stronger for individuals who had worked in that occupation for more than 5 years. This provides a measure of confidence in the results. Also reassuring is the fact that for occupational groups which have been previously studied, associations for which we observed increased risk are generally consistent with the published literature. An approximately twofold risk of meningioma has been previously reported for teachers [McLaughlin et al., 1987; Navas-Acien et al., 2002]. Elevated risk has also been observed for managers and social workers [McLaughlin et al., 1987; Navas-Acien et al., 2002]. A significantly elevated sixfold proportionate incidence ratio was observed for ''garage and gas station attendants'' in a registry-based study of males in Los Angeles County [Preston-Martin, 1989a]. This estimate of effect falls within the range of point estimates we observed for auto body repairers and painters, groups that may have similar exposures to garage attendants. While the increased risk of meningioma that we observed for military workers was not seen for the ''services and military work'' sector in a Swedish historical cohort study [Navas-Acien et al., 2002], this inconsistency might be explained by the fact that the definition of military service in that study was much less specific than our occupational group.

Other occupations for which an increased risk of meninzgioma has been reported are chemists, cooks, carpenters, woodworkers, glassmakers, machine operators, toolmaker setters and operators, inspectors and checkers, technicians, moving equipment operators, motor vehicle drivers, delivery women, computer specialists, social workers, and insurance agents [McLaughlin et al., 1987; Preston-Martin, 1989a; Menegoz et al., 2002; Navas-Acien et al., 2002]. We observed statistically non-significant elevated risks for chemists, drivers, inspectors, and computer programmers, but did not see evidence of an increased risk for cooks, carpenters, woodworkers, or machine operators. While our occupational groups did not specifically identify toolmakers, delivery workers, insurance agents, or moving equipment operators, most toolworkers were placed in the category ''metalworking occupations,'' for which there was no evidence of increased risk. Delivery workers were mainly categorized as drivers, for whom we did see some evidence of increased risk. Insurance agents and moving equipment operators were assigned to various occupational groups, making meaningful comparison unfeasible. Increased risk of acoustic neuroma has been noted previously in occupations with exposure to loud noise [Preston-Martin et al., 1989b]. While it is impossible to make a firm assertion without looking at individual exposure histories, one would not expect an unusually high exposure to loud noise in the occupations for which we observed an elevated risk of acoustic neuroma. It is, of course, possible that our exposure groupings were not sensitive enough to detect an increased risk for noise exposure if individual exposure to noise varied more within occupational groups than between them.

Occupational groups for which we observed elevated OR in this study appear to fall into two broad categories: occupations with an obvious potential for exposure to carcinogens, and occupations for which the observed increase in risk might be better explained by differences in referral or diagnosis. Auto body workers, military workers, and gas station attendants could be exposed to a number of chemical agents, including metals and solvents. Possible exposure to lead [Cocco et al., 1999; Hu et al., 1999; Navas-Acien et al., 2002], and exposure to metal dusts and fumes [Preston-Martin et al., 1989c; Beall et al., 2001] have been associated with risk of meningioma. Prior head injury has been associated with increased risk of meningioma in some studies, but not others [Preston-Martin et al., 1980, 1998;

Schlehofer et al., 1992; Inskip et al., 1998] and may be involved in the increased risk of meningioma in military occupations. Exposure to electromagnetic fields (EMF) has also been postulated as a potential risk factor for brain tumors, but the evidence is inconsistent [Inskip et al., 1995]. Weekly (or more frequent) exposure to benzene, an agent to which gas station attendants are exposed, has been associated with an increased risk of acoustic neuroma [Preston-Martin et al., 1989]. Further assessment of a possible role in brain tumor formation for lead, benzene, and other metals and solvents is warranted, since these agents are known to cross the blood–brain barrier [Inskip et al., 1995; Zheng, 2001; Yokel, 2002]. The International Agency for Research on Cancer (IARC) currently classifies benzene as a known human carcinogen, and lead as a possible human carcinogen.

The increased risk of brain tumor that we observed for athletes, managers, teachers, sales representatives, purchasing agents and buyers, and counselors and social workers could be explained, at least in part, by better diagnosis. Most of these occupational groups involve a sizeable degree of interaction with other people, which might be expected to lead to one or both of the following: (1) earlier noticing of tumor symptoms by individuals with the tumors or by social contacts, or (2) stronger encouragement of the individual to seek medical care. Impaired hearing is a common symptom of acoustic neuroma, and frequent social contact leading to enhanced diagnosis might be more likely for this group. Symptoms of meningioma (such as headache and seizures) are more likely to be noticed by individuals themselves. Managers, teachers, and counselors tend to be better educated, and might be more likely to be diagnosed since they have a higher awareness of health status, the potential benefits of care, and access to care. While the apparent increased risk of acoustic neuroma in athletes might be explained by a true biological difference, a possible alternate explanation is that athletes are keenly aware of changes in balance or other sensory perceptions, since their performance depends on it. As a result, they might be more likely than the general population to detect signs and symptoms of a neuroma.

An analysis of the risk of glioma by occupational group was conducted previously in this case-control study [De Roos et al., 2003], allowing comparison of occupational associations for the different brain tumor types. Designers and decorators had an elevated risk of all three tumor types (OR = 4.7 for glioma, OR = 4.9 for meningioma, and OR = 5.5 for acoustic neuroma). This diverse group (including interior designers, florists, graphic design artists, and printers) had no obvious common exposure. Risk for general farmers was significantly elevated for glioma, non-statistically significantly increased for meningioma, and unassociated with acoustic neuroma. Dissimilarities were particularly striking for auto body repairers and auto body painters, where an association was seen for meningioma, but not for glioma (no cases of acoustic neuroma were reported in these groups). Elevated risk in military occupations was restricted to meningioma, and elevated risk in athletes was seen only for acoustic neuroma. Although differences in the observed associations between the tumors could be due to chance fluctuations in the data, it does appear that risk factors are different for the different tumor types. This underlines the importance of tumor-specific analyses in future studies of brain tumors.

Exposure assessment in this analysis was limited to the assignment of subjects to occupational groups based on their histories of jobs held. While this has the advantage of avoiding recall bias that could be introduced by asking subjects direct questions about exposure to specific agents, an obvious disadvantage is that specific occupational exposures were not addressed. A more detailed look at the data would involve assigning individual exposure to specific occupational agents based on each subject's detailed occupational history, including information on job processes, chemical agents used, protective equipment used, and important determinants of exposure. Such an endeavor requires an enormous investment of time, as well as expert input from trained individuals knowledgeable about workplace exposures. The analysis presented here is the first step in a more comprehensive and detailed evaluation of occupational exposures and risk of brain tumors for this study [Stewart et al., 1996]. The results of the occupational group analyses reported here for meningioma and acoustic neuroma, and reported previously for glioma [De Roos et al., 2003] will guide detailed exposure-specific analyses for specific occupational agents, including lead, chlorinated solvents, EMF, and pesticides.

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